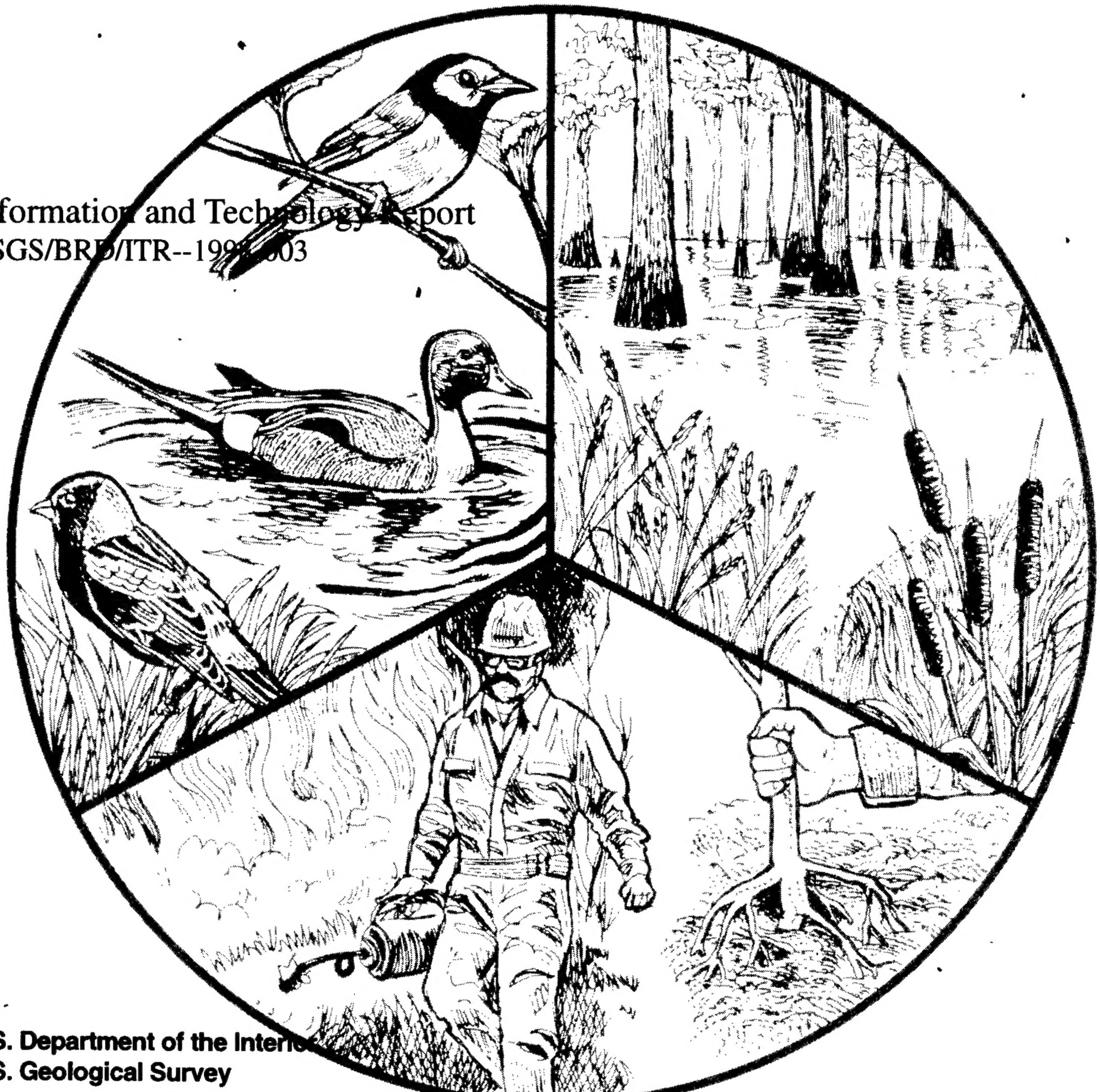
Selecting Habitat Management Strategies on Refuges



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Introduction

This report is a joint effort of the Biological Resources Division, U.S. Geological Survey and the U.S. Fish and Wildlife Service (FWS) to provide National Wildlife Refuge (NWR) managers guidance on the selection and evaluation of habitat management strategies to meet stated objectives. The FWS recently completed a handbook on writing refuge management goals and objectives (U.S. Fish and Wildlife Service 1996a). The National Wildlife Refuge System Improvement Act of 1997 requires that National Wildlife Refuge System (NWRS) lands be managed according to approved Comprehensive Conservation Plans to guide management decisions and devise strategies for achieving refuge unit purposes and meeting the NWRS mission. It is expected that over the next several years most refuges will develop new or revised refuge goals and objectives for directing their habitat management strategies.

This paper outlines the steps we recommend in selecting and evaluating habitat management strategies to meet specific refuge habitat objectives. We selected two examples to illustrate the process. Although each refuge is unique and will require specific information and solutions, these two examples can be used as guidance when selecting and evaluating habitat management strategies for other refuge resources:

Example 1. Management of floodplain woods habitat for forest interior birds. The biological resource of concern is the quality and quantity of floodplain woods habitat for eastern forest interior birds in the Cypress Creek NWR (U.S. Fish and Wildlife Service 1996b).

Example 2. Management of habitat for biodiversity: Historical landscape proportions. The biological resource of concern is the change in diversity associated with man-induced changes in the distribution and abundance of habitat types at the Minnesota Valley NWR (U.S. Fish and Wildlife Service 1996c).

Habitat as a Basis for Refuge Management

The focus of this paper is management of habitat on refuges. Habitat management involves the manipulation of vegetation, water, and other biotic and abiotic factors for the benefit of target animal communities. Long-term habitat conservation and management are essential to the conservation of biodiversity across the United States.

The presence of high quality habitat is a necessary prerequisite for, but does not guarantee, an abundant wildlife population. Inadequate habitat, however, will cause wildlife to be absent or less abundant. For example, a

refuge may contain very high quality habitat for certain migratory species, but these species may not actually occur on the refuge at a given point in time because of poor conditions on wintering grounds, extreme weather during migration, or other factors not related to habitat conditions on the refuge. Similarly, a refuge may have good habitat for resident species, but certain species' population levels may be low due to local disease outbreaks or high levels of pollution. In both cases, when the extreme weather, disease, or pollution abates, the habitat base is there to provide for the wildlife. On the contrary, if a refuge has inadequate habitat, wildlife will be absent or occur at very low levels, regardless of the timing or duration of other factors such as weather or disease. This is especially true when considered over long periods of time.

> **The highest levels of wildlife abundance and diversity, over time, can only be achieved when an adequate habitat base**

Because wildlife populations are affected by factors other than habitat, a logical goal of habitat management is to focus on the habitat conditions required to provide the greatest potential for the species or resource of concern. To the extent that limiting factors other than habitat can also be successfully managed, the greater the likelihood that the species or resource will actually reach the limits imposed by the habitat.

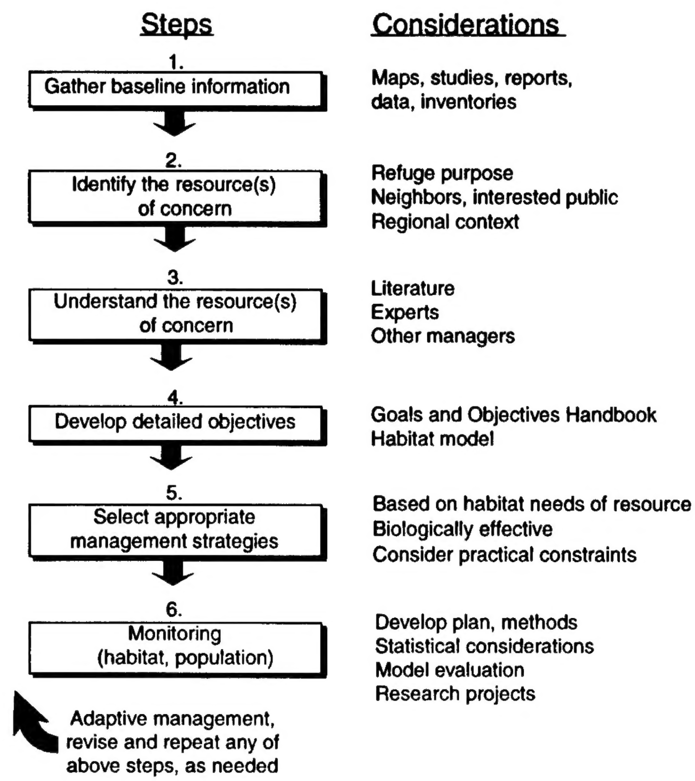

Fig. 1. Steps and considerations in selecting habitat management strategies.

Overview of Recommended Steps

We recommend six steps be followed in the overall process of managing habitats on National Wildlife Refuges, applied within the context of adaptive resource management (Fig. 1). We focus on Steps 1-5 in this paper. Step 6, monitoring, will be discussed in only a general fashion. Specific, detailed recommendations on monitoring standards and protocols will need to be developed in a separate document.

Habitat management on refuges is an ongoing process, and the Fish and Wildlife Service recommends that planning be conducted within the context of adaptive resource management (U.S Fish and Wildlife Service 1995a, 1996a). The steps outlined here are not intended to imply that planning is a one-way, linear sequence of events. Adaptive resource management can be applied at any point in the six steps. For example, resources of concern may change over time, as more is learned about habitats, wildlife populations, or ecosystems. This could result in changes in objectives or strategies. In addition, management may change based on the results of detailed research level studies or in response to obvious successes or failures. Adaptive management requires an ongoing commitment to evaluate and monitor the effects of habitat management strategies and incorporate new knowledge into updated plans and approaches. Haney and Power (1996) provide a detailed description of applying adaptive management principles on the Necedah National Wildlife Refuge.

Gather Baseline Information

An early step in any refuge management activity is gathering the necessary and available baseline information. The geographic area of concern must be defined and should include refuge lands and any adjacent lands that might affect important wildlife resources on the refuge. For the area of concern, the following types of baseline information should be sought:

- descriptions of all habitat types
- maps showing the location and extent of the habitat types
- other pertinent resource maps, including soils, streams, roads, etc.
- existing literature searches or summaries related to important biological resources

- inventories or lists of wildlife species known to occur in the area, along with season of use, habitats used, types of use (e.g., nesting, feeding, roosting)
- climate data
- historical information, including past land use and extent
- information on species of special concern [e.g., state or federal threatened or endangered species, National Audubon Society WatchList (National Audubon Society 1996), list of nongame birds of management concern (U.S. Fish and Wildlife Service 1995b)]
- information on the types, frequency, and effects of the driving biotic and abiotic processes for each plant and animal community
- exotic species of concern - location and extent
- other information pertinent to the region and refuge.

Geographic Information Systems (GIS) can be useful in compiling available digital map data and in identifying the landscape or regional context of the refuge.

The baseline information provides a foundation for identifying and understanding the specific biological resources that are important in the system. Many refuges have collected large amounts of such information over many years, and making use of this storehouse of knowledge will save time and money. Refuges with scant or inadequate baseline information may need to invest in acquiring key information before proceeding.

Identify the Resource(s) of Concern

Identification of the resource(s) of concern is necessary to: (1) focus management effort on critical issues; (2) avoid directing management effort toward resources that are not logical to manage on the refuge; and (3) ensure that involved parties agree on management direction. There is no single correct answer to the question of identifying the resources of concern. This is essentially an exercise in determining current human values. Whereas a refuge may have had an historical interest in waterfowl population levels, today's values may dictate that habitat for declining amphibians is also of concern.

Identification of resources of concern on an individual NWR must be accomplished within the overall framework of the NWRS. Important considerations include the mission of the NWRS, regional and ecosystem goals of the FWS, the station mission, and the enabling legislation for the NWR. In addition, outside interest groups should have input in determining the important resources. Haney and Power (1996) note that interest groups may include local residents, consumptive and nonconsumptive recreational users, environmental groups, businesses and industries that rely on local natural resources, area schools, and government officials. Meetings and surveys may be helpful in sharing information and determining the knowledge and opinions of interested groups.

Specific habitat management strategies may vary depending on which resources are considered to be most important. Where the goal is to preserve a natural abundance and diversity of flora and fauna, habitat management must accommodate a broad array of species. Where the goal is habitat management for a subset of species, habitat management strategies need only be shown to improve conditions for the desired subset. When management is directed at a subset of species, however, it is important to understand and consider the effects of these actions on nontarget species. It may be realistic to assume that habitat management directed at a specific subset of species (e.g., declining grassland birds) will also encompass the needs of many other species that use the habitat. However, knowledge of the effects of habitat manipulations and species responses may be tenuous. The more complete the understanding of the habitat needs of all species, the clearer the understanding of the effects of any management action will be.

Refuges may be required, under legislative mandate, to manage certain resources. There is often some degree of latitude in interpreting these mandates. Explicitly defining and describing the resource of concern will guide habitat management efforts and provide an opportunity to discuss and debate the importance of various resources or approaches. Identification of the resources of concern can be facilitated by posing a series of questions, such as those suggested by Schroeder and Keller (1990:2):

- Is the rarity of a species or community (plant or animal) of concern?
- How important are endemic species/communities?
- Is the changing abundance of species/communities important?
- Is species richness of interest?
- Should ecosystem functions be considered?
- Are keystone species present?
- Which species or communities are the best indicators of change in the ecosystem of concern?
- Can "natural conditions" be defined, managed for, or monitored?
- Are cumulative effects to be considered?
- Are there major landscape level changes to be considered?

Specific answers to these questions will vary across refuges because of differences in geography, habitat types, land uses, wildlife species, refuge purposes, refuge history, and local and regional concerns. Identification of the important resources should also consider the larger landscape within which the refuge occurs. The refuge may provide a critical habitat link that is important on a regional, national, or flyway scale. The rarity or abundance of a habitat type or species will vary depending on the relative scale of interest. The logic behind selecting specific resources as targets of management efforts should be clearly documented, to provide a record of the decisionmaking process.

Understand the Resource(s) of Concern

Following identification of specific resources of concern, refuge managers should acquire as much information as possible about these resources. By understanding the dynamics and ecology of the plant and animal communities within the refuge, managers can more reliably predict the outcome of management actions. The initial investment of time and resources "up front" will pay off with better designed and executed projects on the ground.

If the resource of concern is defined as habitat to support a natural abundance and diversity of plants and animals, for example, information related to the habitat types, plant and animal species life histories and habitat needs, and dynamics of the system should be acquired and summarized. The Bear River Migratory Bird Refuge Comprehensive Management Plan includes detailed charts of bird species use (nesting, feeding, etc.) of various habitat types (e.g., deep emergent marsh) as well as season of use (U.S. Fish and Wildlife Service 1997). A synopsis of a meeting to establish habitat goals and objectives for the Monte Vista and Alamosa National Wildlife Refuges included detailed supporting information concerning plant communities; shorebird, waterfowl, and sandhill crane seasonal habitat use; and additional details on habitat use by key species (Monte Vista and Alamosa National Wildlife Refuges 1996). These types of summary data can be very helpful in understanding how and when wildlife use the available habitat.

The manager must understand the species, community, or system prior to selecting and implementing a management action, or the effort is likely to be ineffective.

Much useful information already exists regarding the ecology and dynamics of many different ecosystems and habitats. It can always be said that more information is needed, but it is also true that we must make the best use of what we do know and understand. A wealth of information exists related to the habitat requirements of individual wildlife species. For example, information on the habitat requirements of over 100 species is available in the Habitat Suitability Index (HSI) model series (Schamberger et al. 1982). These or other habitat models may provide clear summaries of the habitat needs of species of concern. Community profiles synthesizing the available literature for selected ecosystems exist for many areas, including red maple swamps (Golet et al. 1994), salt marshes (Teal 1986), stream and riparian habitats (Minshall et al. 1989), prairie basin wetlands (Kantrud et al. 1989), and bottomland hardwood swamps (Wharton et al. 1982). In addition, a vast amount of information can be obtained through the Internet from libraries, research centers, universities, and agencies.

We strongly recommend that refuge staff conduct literature searches, search the Internet, seek materials from local universities or research centers, and discuss their needs with other nearby refuges. It is important that adequate time be devoted to acquiring and understanding existing information. A very useful outcome of this process is the identification of information gaps. When data are scarce or from geographically disparate regions, a decision must be made on how much information is required before moving forward with management actions. If the habitat, species, or issue is of special concern, it may be necessary to acquire additional data before starting management activities. Additional information may be acquired through workshops involving local and regional experts, or through specific on-the-ground studies of the resource. Site-specific studies, although time consuming, will produce the most reliable information for future management.

Develop Detailed Objectives

For a given resource of concern, goals and objectives should be defined, meeting the criteria outlined in the FWS Handbook (U.S. Fish and Wildlife Service 1996a). Resource goals are generally stated in broad, general terms. More detailed resource objectives should be based on a thorough understanding of the biological and habitat issues related to the resource.

An important consideration in establishing objectives is to understand the dynamics of the habitat type or system of concern. For example, many wetland systems are highly variable from year to year, depending on precipitation levels. Some

A clearly defined habitat objective is necessary to guide management efforts and make it possible to measure progress toward attainment of objectives.

wetlands benefit from periodic drying. A wetland habitat objective should consider emulating the naturally occurring dynamic patterns, over an appropriate spatial and temporal scale, and not necessarily attempting to maintain a constant condition. In all cases, habitat objectives should reflect a detailed understanding of the biology of the habitat or system of concern.

Where possible, objectives should be stated in quantitative, measurable terms, so that progress toward their attainment can be objectively assessed. Noss and Cooperrider (1994), however, caution that objectives must be ecologically relevant, and not chosen solely based on their measurability. DeLong (1995) provides a case study from the Hart Mountain National Antelope Refuge describing the importance of developing wildlife objectives from a sound ecological base. He suggests conducting a detailed problem analysis to help identify the underlying reasons why desired conditions are not being achieved.

We recommend the use of a well-documented and consistent approach to provide a rigorous framework for setting objectives. One possibility is to use models. There are a number of species models available [e.g., HSI models (Schamberger et al. 1982), Habitat Capability Models (Verner and Boss 1980)]. Fewer community level models exist (see Schroeder 1987; Schroeder and Haire 1993). Simulation models have also been used to guide refuge management strategies (Hamilton et al. 1985, 1986). Haney and Power (1996) present a model that integrates political and technical feasibility with efficacy to evaluate savanna restoration potential at Necedah NWR in Wisconsin.

A documented model can consist of a very specific mathematical approach, a detailed list of criteria with limited mathematics, or a schematic presentation. It may be possible to locate models developed by states, universities, or local entities, or to work with others to develop new models. Schroeder (1987) reviewed concepts and approaches for community models, and Schroeder and Haire (1993) provide general guidelines on the development of community-level habitat models. A primary benefit of using documented models is that they provide a very clear and explicit expression of the logic and assumptions used in guiding management actions. The selection of any management action implies an understanding of the relationship between the action, the habitat, and the wildlife resource. A documented model serves to record this understanding, which allows for improved communication and the formulation of testable hypotheses. Potential problems with models may be related to concerns about their accuracy, flexibility, or level of detail.

At this point in the process, users would benefit from a thorough critique of the quality of their habitat objectives before proceeding. Useful questions to ask during the critique of habitat objectives are:

- Is each part of the objective clear and unambiguous?
- Can progress toward the objective be measured?
- Is the objective derived from the resource goal?
- Is there well-documented logic or science to support the objective?

The best objectives lay out a clear path for subsequent management actions and leave no room for misinterpretation. The worst objectives provide little or no focus and are largely subject to the interpretation of the reader.

Select Appropriate Habitat Management Strategies

After the biological and habitat issues are understood and an objective has been specified, the next step is to determine appropriate management strategies. Existing sources (e.g., Fredrickson and Taylor 1982; U.S. Fish and Wildlife Service 1982; Rutherford and Snyder 1983; Cross 1988; Payne 1992; Berkey et al. 1993; Bookhout 1994) should be consulted for ideas on appropriate and proven management strategies. In addition, discussions with resource experts and other land managers will often help in determining the best strategies.

We recommend following four steps in selecting appropriate habitat management strategies:

1. Determine which features of the habitat need to be managed and if it is feasible to manage them on the refuge.
2. Determine management strategies that can be used to influence these important aspects of the habitat.
3. Select the most effective strategies given the practical constraints of the project.
4. Consider the effects of the strategy on nontarget organisms.

Determination of which aspects of the habitat can, and need to, be managed is based on a comparison of desired conditions with existing conditions. Knowledge of what constitutes the desired conditions is a prerequisite, obtained from understanding the resource(s) of concern. Habitat management should be directed first at those factors that are limiting for the resource of concern. Limiting factors can be identified by using documented criteria or a model that describes the desired habitat conditions.

Baseline conditions at the refuge can be assessed using the criteria or the model to determine the relative quality of the habitats. A detailed model is most useful, but is not absolutely essential for this assessment. A simple listing of habitat needs may be sufficient for the comparison. It may be possible to consult local or regional experts and develop specific, documented habitat management criteria based on their professional judgment.

If it is likely that a management strategy will successfully create the desired habitat condition, that strategy should be considered. If, however, implementation of the management strategy will not lead toward the desired habitat condition, the strategy should be avoided. In this manner, the range of possible management actions becomes clear, and is limited to those with known effectiveness. The effectiveness of various strategies in creating specific habitat conditions may sometimes be learned from the literature or other published sources. Often, however, this information is best obtained from other managers or researchers familiar with the strategy and habitat.

Difficulties can arise when the relation between a management strategy and the desired habitat condition is unknown or poorly understood. In such cases, implementation of the management strategy could lead to unintended consequences. In many instances, what is known about the effectiveness of a specific management strategy applies directly only to situations that closely mimic the conditions where the original studies were conducted. Extrapolation of this information to new situations, different local conditions, different management timing, etc., can lead to different outcomes. Additional research or information gathering may be required to determine the effectiveness of poorly understood strategies.

Practical considerations in selecting management strategies include assessing costs (in both time and money), equipment needs, expertise, maintenance requirements, timing relative to the ecology of the system, and the need for public involvement (where strategies may be of concern to the public). Often there will be tradeoffs between the most effective and most practical management strategies. For example, the most biologically effective strategy may be too time consuming or costly to implement. In general, managers should select the most effective strategy possible within the practical constraints that exist.

All areas cannot be treated at once and managers must consider how to prioritize individual parcels for application of specific strategies. Important considerations might include:

1. The amount of land area involved. It may be desirable to start with small parcels and learn by experience. Or it may be desirable to work on the largest parcels to maximize the area treated.
2. The time frame for the expected changes. Highly degraded areas may take very long to recover, whereas less degraded areas may recover faster.
3. The likelihood of success. Certain parcels may be more or less likely to respond favorably to certain strategies.

Monitor the Effects of Habitat Management Strategies

On-the-ground effectiveness of habitat management strategies can best be determined by periodic monitoring. A plan should be developed to describe the methods, frequency, and specifics of the monitoring program. A distinction should be made between measuring the effectiveness of a strategy in creating the desired habitat conditions and the effectiveness of these habitat conditions in modifying wildlife populations. As noted in the Introduction, we will not provide all of the detailed guidance needed to implement monitoring across the NWRS. Our intent here is to discuss the importance of monitoring and the difference between monitoring habitat conditions and wildlife populations.

Effective monitoring of habitat management strategies should first focus on assessing changes in the habitat and then on an evaluation of the response of the targeted animal populations. The initial question should be "Did the management strategy result in the desired habitat condition?" This question can be answered by sampling the treated area to determine its condition after the treatment. In addition, it may be important to determine that any observed changes were indeed a result of the management strategy. It is possible that similar changes occurred in untreated areas. This level of sampling may require untreated control sites that are otherwise similar to the treatment areas. Valid statistical sampling of both treatment and control areas will often be infeasible due to constraints of time, personnel, and money. Where control sites are not feasible or warranted, treated areas should be assessed with a sampling scheme that yields a result at an acceptable level of statistical confidence, thereby providing a known degree of certainty. If statistically valid monitoring of treated areas is not possible, reasonable effort should still be made to determine the effectiveness of management strategies. Visual observation, along with field notes and appropriate qualitative or quantitative descriptions can be useful in determining the direction of change.

It may be possible to use GIS for some aspects of monitoring, such as monitoring changes in habitat con-

ditions that can be reasonably measured from remotely sensed or other available GIS data. For example, assume a habitat management strategy was implemented to change cropland habitat to forest habitat. The area and spatial arrangement of these habitats could be readily assessed and monitored over time with a GIS.

If the desired habitat response has been obtained, it may then be necessary to evaluate the response of the wildlife population(s) in relation to the management action. This decision will be based on the degree of confidence that the habitat changes are known to affect the wildlife resource of concern. If the habitat criteria or model used to set objectives and guide the selection of management strategies has a known and acceptable level of reliability, then further monitoring may not be needed. If such is not the case, the monitoring effort can be used as a test of the habitat criteria. If possible, this effort should be based on a level of sampling that provides an acceptable level of statistical significance. The magnitude of the wildlife response will depend on the extent to which the specific changes in the habitat conditions influence the population. For migratory species, conditions off the refuge may have a strong influence on wildlife population levels. In addition, nonhabitat factors such as weather, disease, or contaminants may negatively affect populations. In such cases, improvement in habitat quality may not result in increased populations on the managed lands at a given point in time. These habitat improvements, however, should raise the potential population to a higher level over time (i.e., they identify a habitat-imposed upper limit to population levels). Long-term studies of populations are often needed to sort out the influences of habitat versus nonhabitat factors.

The concept of habitat-imposed limits on wildlife populations has very important implications in understanding the relationship between management strategies and animal populations, and in the analysis of monitoring data. There is a growing body of literature that addresses the statistical interpretation of this concept (Terrell et al. 1996; Thomson et al. 1996; Cade et al., in press). Where habitat quality imposes an upper limit on the resource of concern, traditional statistical analyses with linear assessments of central tendency (e.g., ordinary least squares regression) may not provide the most pertinent information.

Example 1 - Management of Floodplain Woods Habitat for Forest Interior Birds

Introduction

Cypress Creek NWR was established in 1990 in the Cache River watershed in southern Illinois (U.S. Fish and Wildlife Service 1996b). This refuge provides important habitat for a large number of species and primary purposes of the refuge include supporting the North American Waterfowl Management Plan, providing habitat for waterfowl and other migratory birds, and providing for biodiversity. An important resource identified on the refuge is the neotropical migratory bird group. These birds benefit from extensive stands of hardwood forests and a major focus of refuge habitat management will be the acquisition and restoration of additional floodplain woods.

The example we develop below uses the Cypress Creek NWR Comprehensive Management Plan as a framework, with additional pertinent citations, discussions, and explanations. Our goal is to relate the six steps to a real world example, while at the same time providing additional details helpful in the implementation of specific habitat objectives. This example uses a specific model to provide the structure for a detailed habitat objective.

Gather Baseline Information

The Comprehensive Management Plan for the refuge describes the floodplain woods as, historically, the largest natural community type on the refuge. Other major community types include upland forests, herbaceous wetlands, swamps, and deep water habitat. The Plan provides baseline information on threatened and endangered species on the refuge, numbers of species in major vertebrate groups, general descriptions of the plant communities, and an illustration of the larger landscape within which the refuge exists.

Identify the Resource(s) of Concern

The Cypress Creek NWR Plan indicates that many forest songbirds have been negatively affected by forest fragmentation, resulting in reduced populations and lower reproductive success (U.S. Fish and Wildlife Service 1996b). Forest interior birds nest within the interior of forests and rarely near the edge (Freemark and Collins 1992). Many forest interior bird species in Eastern deciduous forests have experienced population declines in recent years (Askins et al. 1990; Hill and Hagan 1991; Robinson 1992; Sauer and Droege 1992; Peterjohn et al. 1995). The degree of population decline varies between studies, regions, and for different periods of analysis (James et al. 1996).

Understand the Resource(s) of Concern

A great deal of information has been published concerning forest interior birds (see Martin and Finch 1995). Therefore, only a few sources of most relevance to refuge managers are summarized here.

Spatial Relationships

Habitat patch size and shape. Species richness of forest interior birds is positively correlated with forest patch area (Whitcomb et al. 1981; Askins et al. 1987; Freemark and Collins 1992). In addition, birds requiring forest interior habitat are not distributed randomly with regard to patch size (e.g., Blake 1991). Many forest interior species occur only in the largest patches. The shape of forest patches can influence both the abundance and productivity of forest interior birds. Patches with larger amounts of core (interior) habitat and less edge had a higher abundance of interior bird species (Temple 1986). Negative effects of forest edge may include higher rates of predation, competition, and nest parasitism by brown-headed cowbirds (*Molothrus ater*); reductions in pairing and nest success; and changes in microclimate and microhabitat conditions (Faaborg et al. 1995).

Habitat isolation. The degree of isolation of forest patches can affect their use by forest interior birds. Patch isolation is a function of interpatch distance and the characteristics of the landscape between patches (Knaapen et al. 1992). Forest patches that were less isolated had higher species richness of interior birds in a study of eastern forests (Whitcomb et al. 1981), and deforestation around patches may cause interior birds populations to decline (Askins and Philbrick 1987). Increased regional abundance of forest may positively affect forest interior bird abundance (Robbins et al. 1989).

Although birds generally have high dispersal capabilities, the landscape surrounding a forest patch can influence their distribution. Forest interior bird richness was lower in patches surrounded by urban development than patches surrounded by agricultural land (Whitcomb et al. 1981). Habitats in adjacent lands that provide at least marginal existence for target species are thought to be more valuable for dispersal than narrow connecting corridors (Wilcove et al. 1986).

Key Spatial Features Required by Forest Interior Birds

- **Larger forest patches support higher species richness.**
- **Patches with more interior habitat are preferred.**
- **Patches surrounded by habitats that allow dispersal are best.**

Habitat Structure

Lynch and Whigham (1984) summarized the habitat preferences of 15 neotropical migratory birds (the majority of which were forest interior species) as mature forests with high plant species richness, tall canopies, and well-developed herb and shrub layers. Ambuel and Temple (1983) noted that high levels of foliage height diversity were important to forest interior bird richness. The basic habitat needs of 19 forest interior birds in Maryland would be provided for in a closed canopy, mature forest, with a mix of dense and open understory conditions (Schroeder 1996a).

Key Structural Features of Forest Interior Birds

- **High levels of foliage height diversity**
- **Tall canopies**
- **Closed canopy**
- **Mix of dense and open understory**

Management Options

Faaborg et al. (1995) provided the following general management guidelines to counter the effects of habitat fragmentation on neotropical migrant songbirds:

- preserve large fragments
- maximize the amount of core (interior) habitat
- maximize vertical diversity
- use insecticides cautiously
- concentrate recreational use into designated areas

Lynch (1987) noted that increasing the effective size of forest patches may counter the negative effects of isolation. Effective size can be increased by:

- increasing contiguous patch size
- establishing compatible land uses in adjacent lands
- increasing the amount of forested land within a region

The spatial and habitat aspects of these recommendations have been quantified in a community habitat evaluation model for palustrine forested wetlands in Maryland (Schroeder 1996a). This community model could be used both to quantify existing values of forest patches and to develop specific management actions to improve conditions. The spatial portion of the community model uses a modified species-area relationship (Schroeder 1996b) and key features of the tract portion of the model are summarized in Fig. 2. Each forest tract is rated on a 0-1 scale based on its area and modified by the degree of core habitat and isolation. A test of the tract portion of the model indicated significant positive relationships between the frequency of occurrence of forest interior birds and the model tract suitability index (TSI) ($R^2 = 0.503$, $P = 0.001$). The tract portion of this model has not been tested specifically in southern Illinois. Additional site-specific data would be useful to determine if there are any geographic differences that should be incorporated into the model.

Develop Detailed Objectives

The Cypress Creek Comprehensive Management Plan calls for restoration of several hundred acres of forest over a 5-year period. The Plan does not, however, provide details on the criteria that will be used to guide the implementation of restoration efforts. For this example, we will assume that the refuge will develop a habitat objective based on the tract portion of the community habitat evaluation model (Schroeder 1996a), in order to benefit forest interior birds. Therefore, a reasonable forest

Tract Suitability Index (TSI) = (2.227 x effective tract area$^{0.273}$)/19.8

Tract = a contiguous unit of deciduous palustrine forested wetland, including the com bined habitat of forested wetlands joined by corridors, bounded by an area >10 m wide consisting of either nondeciduous palustrine forested wetland or a barrier to species movement

(Note: tracts with effective areas >3,000 ha should be assigned a TSI of 1.0)

Effective Tract Area = (measured tract area x core area factor x isolation factor)

Measured Area = the actual area (in ha) of an individual tract

Core Area Factor = 0.15 + (0.85 x % core area (decimal form))

Core Area = the area of a tract that is 100 m or more from a tract boundary that is bordered by nonforested habitat

Isolation Factor = (permeability factor x % deciduous forested wetland factor)

Permeability Factor = a factor relating to the ability of the adjacent habitat to be traversed by wildlife species to accommodate dispersal and movement

% deciduous forested wetland factor = 1.0 + (percent deciduous forested wetland within 2 km of tract boundary (decimal form) x 1.55)

Fig. 2. Summary of tract portion of deciduous forested wetland community model (Schroeder 1996a).

interior bird habitat management objective could be stated as:

> The refuge will use the forested wetland community model (Schroeder 1996a) and seek to maximize the Tract Suitability Index to provide improved conditions for forest interior birds.

Select Appropriate Habitat Management Strategies

The Tract Suitability Index in the community model reflects the size and spatial arrangement of forest patches. Application of the model to the baseline conditions would indicate which landscape features limited the model score. These features would be a logical starting place for initial management efforts.

The effective size of patches can be enlarged by increasing the size of contiguous patches, increasing the core area of the patch, or decreasing isolation of the tract. Faaborg et al. (1995) note that the size of small fragments can be increased by reforestation through natural regeneration or planting. They recommend selecting areas for afforestation that will maximize the amount of forest interior habitat. Thus, both contiguous size and core area can be increased in this manner and would maximize benefits. The degree of tract isolation can be improved by increasing the permeability of adjacent habitats or increasing the amount of forested wetland habitat within the 2 km buffer area.

Each of these management actions involves reestablishment of forested or forested wetland habitats. The model can be used to determine where these habitats should be recreated to maximize the gain in the model score. Knowledge of the historical landscape is important in determining where these habitats previously existed and might be most likely to be successfully reestablished.

There are many factors to be considered in reestablishing forested or forested wetland habitat. Users are encouraged to seek site-specific information and local expertise to guide their specific projects. The following information is provided as a general guide to reforestation projects:

1. Complete a detailed description of existing conditions, including vegetation structure and composition, soil types, topography, and flooding regime.
2. Determine the specific objective for the reforestation effort in terms of the desired conditions of woody and herbaceous vegetation structure and composition.
3. Consider potential problems, such as the effects of exotic vegetation, deer browsing, or residual herbicides.
4. Determine if the best strategy is to plant seeds, plant seedlings, or encourage natural regeneration. Use a local source for seeds or seedlings for the best results.

Additional guidance can be found in publications related to reforestation (e.g., Haynes et al. 1988; Allen and Kennedy 1989; Robertson and Robertson 1995).

Monitor the Effects of Habitat Management Strategies

The spatial and temporal scales of reforestation indicate a long-term approach to monitoring is required. It will take many decades to recreate large areas of mature forest habitat. Important goals might be to monitor the initial success of planting or seeding and to make necessary adjustments in the early stages of the effort. In the long term, it would be necessary to determine if all areas were successfully reforested. At the point in time when the forest conditions approximated what was desired, measures of the abundance of forest interior birds could be taken. Because of the long time-frame involved, it would be difficult to modify the approach if it was determined that forest interior bird response was poor. This reinforces our point concerning the importance of having the best knowledge possible before applying specific management strategies. Another approach to monitoring the effects of reforestation would be to census birds annually and document changes and trends in interior bird species as the reforested area matures.

Example 2 - Management of Habitat for Biodiversity: Historical Landscape Proportions

Introduction

Minnesota Valley NWR has adopted a Landscape Plan to help attain the refuge goal of perpetuating the natural diversity and abundance of wildlife species and ecological communities (U.S. Fish and Wildlife Service 1996c). The Plan was developed with the assistance of

local natural resource professionals and represents an example of refuge management with a strong focus on biodiversity and ecosystem dynamics. This focus is consistent with requirements of the National Wildlife Refuge System Improvement Act of 1997 to maintain the biological integrity, diversity, and environmental health of the refuge system.

In this example, we use the Minnesota Valley NWR Landscape Plan as a framework, with additional pertinent citations, discussions, and explanations. Our goal is to relate our recommended six steps to a real world example, while at the same time providing additional details to allow easier extrapolation to other locations or situations.

Gather Baseline Information

Baseline information presented in the Minnesota Valley NWR Landscape Plan includes approximations of the current and historic extent and type of habitat types, along with descriptions of major plant communities, exotic species issues, and past management directions. In addition, the larger landscape surrounding the refuge is briefly described. The vegetative cover types on the refuge lands are contained in a GIS data base, which will be updated over time.

Identify the Resource(s) of Concern

The FWS recently adopted an ecosystem approach with a primary goal of contributing to "the effective conservation of natural biological diversity through perpetuation of dynamic, healthy ecosystems" (U.S. Fish and Wildlife Service 1995a). Important components of the approach include perpetuation of natural communities, with naturally occurring structural and genetic diversity, and continuation of natural processes. Noss and Cooperrider (1994) note that conserving ecosystem biodiversity requires maintaining ecologically functional examples of each ecosystem type in a region. Meffe and Carroll (1994) describe the goal of ecological restoration as the recreation of entire systems, including biotic and abiotic components, and the dynamic and functional properties of the ecosystem.

The resource of concern for Minnesota Valley NWR can be described as the patterns and processes of communities and ecosystems that were historically present in that region (U.S. Fish and Wildlife Service 1996a). The Landscape Plan notes that this focus makes it less practical to set wildlife population objectives, especially for the traditional single-species approach. The Plan notes that the refuge land base is not physically capable of compensating for all of the habitat losses occurring outside the refuge and the best strategy is to move towards the establishment of historic habitat acreage.

Understand the Resource(s) of Concern

Determining the patterns and processes of communities and ecosystems that were historically present in an area is a difficult task. Most regions of the United States have been altered, either dramatically or slightly, from historical conditions. Detailed information about past conditions may not be readily available or of high quality.

Important first steps in the effort to describe historical patterns or processes should include: (1) identification of the period in time that represented the desired conditions; (2) identification of the ecosystem processes or patterns that have been altered and for which a change is desired and feasible to implement; and (3) identification of the desired restored state for these processes or patterns.

Identification of the historical time period that represents the desired conditions is a somewhat arbitrary decision, often based on perceptions of when the system was least affected by human disturbance. Many ecological restoration efforts focus on reestablishing the structure of the system, and not directly on system functions, because the latter are much more difficult to measure and are unknown from a historical perspective. Knowledge of the historical structure of an ecosystem can sometimes be obtained from original land survey work, explorer's diaries, and early studies. At times, however, such information is not available, and comparisons to undisturbed conditions in more recent times must be made (Robertson and Robertson 1995).

Reestablishing the structure of a system from the habitat perspective involves assessing the overall configuration of the habitats in the landscape and how it has changed over time. The Minnesota Valley NWR Landscape Plan (U.S. Fish and Wildlife Service 1996c) uses historical records to identify the proportions of habitat types on refuge lands that existed prior to European settlement.

Noss and Harris (1986) describe a general goal of maintaining the regional species pool and the pattern of its assembly under natural conditions. They note that although we lack the information necessary for such a detailed characterization of most systems, in most cases we can make a good guess at what "native diversity" would be. Meffe and Carroll (1994:412) note: "The fundamental goal of restoration ecology is to return a particular habitat or ecosystem to a condition as similar as possible to its pre-degraded state." To accomplish eco-

logical restoration, knowledge of the previous, undegraded condition is needed, including information about system structure (species and relative abundances) and function (interactions, including hydrology and nutrient cycling). Whereas this knowledge is incomplete for most systems, an idea of at least the dominant species present is necessary to set a target for restoration. Gathering historical data in the form of lists of plant and animal species would help to strengthen our assumptions about system structure. Habitat management efforts could then be directed toward providing the structure, composition, and spatial pattern necessary to support native diversity. The depth of knowledge about the historic system partly determines how well it can be recreated and how well the success of the project can be measured.

Develop Detailed Objectives

Planning and implementation of strategies to improve biodiversity can be very complex and time consuming. Meffe and Carroll (1994) note that the product of ecological restoration efforts will often not be an exact replica of historical conditions, but rather will represent positive movement toward that target. The National Research Council (1992, cited by Meffe and Carroll 1994) developed a checklist of questions to help managers involved in ecological restoration projects (Table 1). Use of such a checklist will help guide the entire restoration effort and may lead to more successful results.

The Landscape Plan for the Minnesota Valley NWR expressed an overall goal of managing habitat for biodiversity. The goal was to restore the historical proportions and types of habitats in order to perpetuate wildlife species and ecological communities' natural diversity and abundance.

The derivation of specific objectives for this goal requires knowledge of the proportions and types of habitats that were historically present in the area. In floodplain habitats, the Landscape Plan notes that historic proportions were approximately 30% forest, 30% marsh, and 40% wet meadow. Current proportions are 16% forest, 24% marsh, 40% wet meadow, and 20% cropland. A specific objective is to allow all former and existing cropland to revert to its historic habitat, primarily floodplain forest. Objectives in upland habitats and wetlands/wet meadows on the Minnesota NWR are to restore and enhance degraded habitats. Several small patches of remnant oak savanna occur on the refuge and the objective is to expand the savanna from these parcels into the surrounding mixed forest.

It should be noted that these habitat objectives fall somewhat short of the criteria we outlined earlier for the best objectives. Additional specific details would help to strengthen them. For example, the objectives for wetlands/wet meadow would be improved by specifying how many acres are involved, and exactly what types of restoration or enhancement are desired, and why. Similarly, the objective for oak savanna could be improved by specifying how large an area is desired for the expansion, and what conditions are desired within the savanna type.

Select Appropriate Habitat Management Strategies

Restoration efforts may include strategies such as burning, water management, grazing, seeding, planting, and other manipulations to create desired conditions. Natural regeneration of habitats may provide suitable results in the long term, but results are often slow in coming. Potential difficulties in restoration efforts include the spread of exotic vegetation, herbivore grazing or browsing, poor establishment, or poor vegetative composition. An important aspect of ecological restoration is to provide, over the long term and where feasible, natural disturbance patterns such as periodic fires or flooding.

The Minnesota Valley NWR is working to accomplish the objectives stated above through the application of several specific management actions, selected with the help of local, experienced natural resource professionals (U.S. Fish and Wildlife Service 1996c):

Floodplain Forest Strategies

1. Allow former and existing cropland to revert to its historic habitat, most often floodplain forest, through natural regeneration.
2. Minimize forest habitat fragmentation.
3. Allow natural processes to occur and influence the habitat.

Upland Strategies

1. Remove excess trees for oak savanna restoration and implement prescribed burning in this habitat (Tom Kerr, MVNWR, Bloomington, Minnesota, personal communication).
2. Burn and maintain grasslands only in areas of historical occurrence.

Wetland/Wet Meadow Strategies

1. Use combinations of propagation, ditch plugging, burning, removal of excess sediments, and water control structures to restore or enhance some wet meadow communities.

Table 1. A checklist of appropriate questions for planning, conducting, and evaluating restoration projects [from National Research Council (1992), cited by Meffe and Carroll (1994)].

Project Planning and Design

1. Has the problem requiring treatment been clearly understood and defined?
2. Is there a consensus on the restoration program's mission?
3. Have the goals and objectives been identified?
4. Has the restoration been planned with adequate scope and expertise?
5. Does the restoration management design have an annual or midcourse correction point in line with adaptive management procedures?
6. Are the performance indicators--the measurable biological, physical, and chemical attributes--directly and appropriately linked to the objectives?
7. Have adequate monitoring, surveillance, management, and maintenance programs been developed along with the project, so that monitoring costs and operational details are anticipated and monitoring results will be available to serve as input in improving restoration techniques used as the project matures?
8. Has the appropriate reference system (or systems) been selected from which to extract target values of performance indicators for comparison in conducting the project evaluations?
9. Have sufficient baseline data been collected over a suitable period of time on the project ecosystem to facilitate before-and-after treatment comparisons?
10. Have critical project procedures been tested on a small experimental scale in part of the project area to minimize the risks of failure?
11. Has the project been designed to make the restored ecosystem as self-sustaining as possible to minimize maintenance requirements?
12. Has thought been given to how long monitoring will have to be continued before the project can be declared effective?
13. Have risk and uncertainty been adequately considered in project planning?

During Restoration

1. Based on the monitoring results, are the anticipated intermediate objectives being achieved? If not, are appro priate steps being taken to correct the problem?
2. Do the objectives or performance indicators need to be modified? If so, what changes may be required in the monitoring program?
3. Is the monitoring program adequate?

Post-Restoration

1. To what extent were project goals and objectives achieved?
2. How similar in structure and function is the restored ecosystems to the target ecosystem?
3. To what extent is the restored ecosystem self-sustaining, and what are the maintenance requirements?
4. If all natural components of the ecosystem were not restored, have critical ecosystem functions been restored?
5. If all natural components of the ecosystem were not restored, have critical components been restored?
6. How long did the project take?
7. What lessons have been learned from this effort?
8. Have those lessons been shared with interested parties to maximize the potential for technology transfer?
9. What was the final cost, in net present value terms, of the restoration project?
10. What were the ecological, economic, and social benefits realized by the project?
11. How cost-effective was the project?
12. Would another approach to restoration have produced desirable results at lower cost?

2. Construct small, seasonal catchment type wetlands in the floodplain to simulate the historically present ephemeral wetlands that were filled.

Both the objectives and strategies presented above would benefit from further development. More specific criteria or models would clarify exactly what is desired, where, and why. On the other hand, it may not be possible to develop exact specifications for all objectives and strategies given what is known at this point in time. The Landscape Plan represents a significant change in direction and philosophy from past plans, and the objectives should reflect this shift and allow for a range of successful outcomes within these dynamic systems. The Plan acknowledges this uncertainty and states that habitat boundaries will be dynamic over time. Without more specificity, however, it will be difficult to evaluate and monitor the results of management actions.

Monitor the Effects of Habitat Management Strategies

Habitat management strategies designed to influence both the pattern and process of biodiversity on a large area require a very long time to evaluate. Initial monitoring should attempt to measure whether the habitat is moving in the proper direction. For example, Noss and Cooperrider (1994) suggest that measures of tree size and age class distribution can be used to monitor directional progress in restoring mature forest habitat. For the Minnesota Valley NWR, monitoring of the changes in habitat proportions will determine the rate and success of change. As these directional changes begin to express themselves through features detectable in remotely sensed imagery, a GIS may be useful in tracking composition, spatial pattern, and other landscape features.

As macrohabitat changes take form over many years, it would be desirable to begin to monitor the microhabitat features within each habitat type. This level of monitoring would allow the application of adaptive management principles. For example, assuming that most croplands did revert to floodplain forest at the Minnesota Valley NWR, what new management strategies might be needed to ensure that the internal forest habitat is of high quality? Are there emerging issues related to tree species composition, exotic species, or other concerns? Effective monitoring will provide ongoing opportunities to adjust and refine management.

Conclusions

The planning process being embarked upon by refuges across the nation is an ambitious undertaking. Development and implementation of Comprehensive Conservation Plans will take a commitment of both personnel and financial resources. We hope this paper provides useful guidance to on-the-ground refuge managers, biologists, and technicians in selecting and evaluating the effects of habitat management strategies in relation to specific habitat objectives. In many ways, what we have presented are common sense, rules-of-thumb, and not canned, cookbook approaches. It is clear to the authors that the real decisionmaking has been, and will remain, with the individuals who are actually charged with the day-to-day management of a specific refuge. It is the responsibility of these individuals to conduct their work using the best knowledge and methods available.

There are several points we have tried to communicate throughout our explanations of the six recommended steps:

- Have a vision for the refuge that incorporates national, regional, and local concerns.
- Know and understand the system before doing any work on the ground.
- Involve others.
- Document decisions, methods, and criteria from start to finish.
- Be creative and flexible.

By following the recommended six steps and the points above, it is our hope that habitat management efforts on refuges will result in more defensible, reliable, and successful outcomes.

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13. ABSTRACT (Maximum 200 words) National Wildlife Refuge Lands must be managed according to approved Comprehensive Conservation Plans to achieve specified habitat objectives. Six steps are recommended to guide the process of planning and implementing habitat management strategies: 1) gather baseline information; 2) identify the resource(s) of concern; 3) understand the resource(s) of concern; 4) develop detailed objectives; 5) select appropriate habitat management strategies; and 6) monitor the effects of habitat management strategies. Examples from two National Wildlife Refuges are used to illustrate the six steps. The Cypress Creek National Wildlife Refuge example discusses the management of floodplain forest interior birds. The Minnesota Valley National Wildlife Refuge example describes the management of habitat to restore the historical landscape proportions to conserve biodiversity.			
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